many of us will not agree that "a day will come when the ether will be rejected as useless."

The reader will place the book—if possible the original, but *faute de mieux* its translation—on his shelves with the intention of frequently spending an instructive quarter of an hour with it. Each time he carries out his intention he will realise more the truth of the author's remark: "To doubt everything or to believe everything are equally convenient solutions: both absolve us from the necessity of thinking."

ARTHUR SCHUSTER.

THE INTELLIGENCE OF ANIMALS.

Comparative Studies in the Psychology of Ants and of Higher Animals. By E. Wassmann, S.J. Pp. x+200. (St. Louis, Mo., and Freiburg: B. Herder; London: Sands and Co., 1905.) Price 4*s.* 6*d.* net.

AMONG those who have most carefully and successfully studied the habits and psychology of ants, Father Wassmann occupies a place in the front rank. He has especially devoted his attention to the curious and complicated relations which exist between ants and their domestic animals. Of these, he gives a list comprising no less than 1246 species! Father Wassmann is an accurate and careful observer, and his writings are most interesting.

To show how conscientiously he has studied the ants of his own district I may mention that he made a census of the ants' nests round his home. Many communities have more than one nest. Of *Formica sanguinea*, which he regards as the most gifted of European ants, he records 2000 nests belonging to 410 communities! Most of them have separate summer and winter nests, or rather nests for warm and dry, or cold and wet seasons.

Father Wassmann is by no means one of those who regard ants as exquisite automatons, "devoid even of the simplest sensitive perception and cognition." I quite concur with him—indeed, I expressed the same opinion nearly fifty years ago—that "the life of ants is the climax of development in instinctive life throughout the animal kingdom"; and that "the chasm between the psychic life of animals and that of man, is, in many respects, wider between ape and man, than between ant and man."

Father Wassmann is also, I believe, quite correct in alleging that Buechner and Brehm, and even Romanes, have accepted many statements implying intelligence on the part of animals for which there was no sufficient evidence, some of which, indeed, were quite absurd; and, secondly, that they have in some cases built upon them conclusions for which there is no foundation, and which will not stand the test of critical examination.

On the other hand, I am unable to follow him when he altogether denies to ants any, even the most exiguous, rudiments of intelligence. As in the cases of Darwin and Forel, the conclusion forced upon me has been that animals, and especially ants, do possess some elements of intelligence. In that we agree with the vast majority of those who have studied dogs, elephants, &c.

Father Wassmann defines intelligence as "the power of acting with deliberation and self-consciousness, of inventing new means for attaining various purposes and thus making progress in civilisation." But if ants are descended from an original common stock in bygone times, no one will deny that they have "invented new means for attaining various purposes and thus making progress in civilisation." Moreover, even now we see them adapting themselves to the circumstances of their complex life in a manner which it is surely an abuse of terms to call "instinctive." He admits that the observations of all who have studied ants conclusively demonstrate that ants are not mere reflex machines, but beings endowed with sensitive cognition and appetite, and with the power of employing in the most various manner their innate, instinctive faculties and abilities under the influence of different sense-perceptions. Surely, then, under his definition it is impossible to deny that they have some intelligence.

For instance, in constructing their nests, as Father Wassmann admits, ants do not "cooperate with the regularity of a machine or according to a rigid pattern, but each ant with evident liberty follows her own impulse and her own plan. . . ."

> "As a rule the most zealous and skilful worker is imitated most; her zeal is catching, so that she directs the activity of the others into the same channel."

Indeed, Father Wassmann's fairness and love of truth compel him to make several candid admissions which seem fatal to his position. For instance, an Algerian ant (*Myrmecocystus altisquamis*) has wide open entrances to the nest. A colony, however, which Forel brought to Switzerland, being much annoyed by the attacks of *Tetramorium caespitum*, gradually contracted the doorways. On this Father Wassmann admits that, "as Forel says, these facts afford irrefutable evidence of the great plasticity of ant instinct. For, this instinct is not merely a nervous mechanism forced to operate along uniform lines; it includes sensitive cognition and appetite, which are not only of an organic but also of a psychic nature."

Again, "within these limits, however, we find a wonderful adaptation of means to the end, and at times a marvellous sagacity of animal instinct, which appears nowhere else to such advantage."

> "This phenomenon manifests the marvellous sagacity and quasi-intelligent plasticity of animal instinct, which can hardly be styled 'automatism.' Neither can it be identified with intelligence properly so-called, for this would suppose rational knowledge of the internal laws governing the growth of the ant organism, a knowledge far surpassing even the intelligence of man and entirely beyond the reflections and experience of ants."

Surely, however, if ants have sagacity they must have intelligence. Nor is the attribution to them of "sagacity" an isolated case. Again on p. 157 he says:—

> "Their sagacity is instinctive, essentially different from intelligence and reflection. Ants are in their every action guided directly by sensitive perceptions, not by intellectual ideas. The enigma, therefore, is

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satisfactorily explained by the innate adaptation of their sensitive cognition and appetite, whereas the hypothesis of animal intelligence is unable to offer any solution."

"Instinctive sagacity" seems to me, I confess, a contradiction in terms.

I admit that the subject is one of much difficulty, but if an ant applied Father Wassmann's rigorous criticism to man himself, I am not sure that our boasted gift of reason could be absolutely proved.

No doubt animals do stupid things, but so do we.

Father Wassmann describes what he justly calls the "lovely scenes" in an ant's nest—the care of the young, the "motherly tenderness" shown to the delicate pupæ—but denies that this is any evidence of affection, and contrasts it with the love of a woman or a man for their children. This, he maintains, "is a *rational* love, *conscious of duty* (the italics are his), therefore it is the highest and noblest love existing in Nature." Far be it from me to say a word against either reason or duty. They are amongst the highest qualities of our nature; but surely they have nothing to do with the love we feel for our children, which rests on even nobler feelings.

While fully recognising, then, the accuracy and interest of Father Wassmann's observations, and after carefully considering his arguments, I cannot but recognise in animals some vestiges and glimmerings of intelligence, and maintain, as I did thirty years ago, that "when we see an ant-hill, tenanted by thousands of industrious inhabitants, excavating chambers, forming tunnels, making roads, guarding their home, gathering food, feeding the young, tending their domestic animals—each one fulfilling its duties industriously, and without confusion—it is difficult altogether to deny to them the gift of reason; and the preceding observations tend to confirm the opinion that their mental powers differ from those of men, not so much in kind as in degree."

AVEBURY.

MAXWELL'S THEORY OF LIGHT.

The Electromagnetic Theory of Light. By Dr. C. E. Curry. Part i. Pp. xv+400. (London: Macmillan and Co., Ltd., 1905.) Price 12*s.* net.

DR. CURRY bases his work, which is almost entirely analytical, on Maxwell's equations of the electromagnetic field. These equations suffice to account for the phenomena of electromagnetism, and the book is a discussion of the properties of electromagnetic waves in which the condition that the wavelength is short is generally, but by no means always, introduced. In these equations four vectors are concerned, the electric and magnetic forces, and the electric and magnetic displacements, or, as Dr. Curry prefers to call them, the electric and magnetic moments. The type of equation satisfied by each of these vectors is the same, and it is not necessary for Dr. Curry's purpose to identify the light vector definitely with either. It is another vector satisfying an equation of the same type.

No attempt is made to give a mechanical account of the properties of the ether; it is a medium in which transverse waves of electric and magnetic force are propagated according to the laws indicated by Maxwell's equations; in a crystal, however, of course the direction of the electric force does not lie in the wavefront; the same is true of the magnetic force if the permeability be a function of the direction.

Working on these lines, Dr. Curry has put together a large amount of information as to the analytical properties of such waves. The earlier chapters are entirely taken up with the discussion of the forms defined by certain particular solutions of the equations of motion, for if $\phi \equiv f(r \pm vt)/r$ be a solution, so is $d^n\phi/dx^\lambda dy^\mu dz^\nu$, where $n = \lambda + \mu + \nu$. Some of the solutions thus obtained are of importance in the theory of light, but, as the author states, their interest is chiefly theoretical; and one of his "chief reasons for the elaborate treatment of this particular class of waves has been to indicate another fertile field of research offered by Maxwell's equations."

In chapter iv. we are introduced to the phenomena of interference, treated at first in a simple manner, but applied later to the various kinds of waves the properties of which have already been discussed. The more usual problems of optics first become prominent in chapter v., which deals in the ordinary way with Huyghens's principle and its application to the rectilinear propagation of light. The first difficulty occurs in the attempt to find an expression for the secondary disturbance transmitted from a given element of a primary wave. Such expression may clearly involve the angle ϕ between the normal to the wave and the direction in which the secondary disturbance is being estimated, but the statement that "it is natural to assume that the law of variation of the light vector . . . be according to the cosine of the obliquity of the angle ϕ" is not very convincing, and there seems no reason for calling this law the "natural law of obliquity." The law is, of course, a simple one, and it allows of the analytical solution of various problems which are hardly tractable when a more complex law is assumed; but this is its sole merit. Stokes showed that the true factor is $(1 + \cos\phi)$, and this law is utilised later on; but the physical reason for the change of phase in consequence of which the secondary disturbance from a wave $\sin k(vt - r)$ becomes proportional to $\cos k(vt - r)$ is not discussed as fully as its importance deserves. On these points, reference might with advantage have been made to Prof. Schuster's article in the *Philosophical Magazine,* vol. xxxi.—it is quoted later on another point—or to Lord Rayleigh's article in the "Encyclopædia Britannica." Following this a rigorous proof of Huyghens's principle is given in the usual way from the consideration of the relations existing between certain volume and surface integrals, and the result is applied to optical problems; but the fact that this rigorous analysis leads to Stokes's law of obliquity is not definitely stated, though it follows at once from the formulæ on p. 176.

Diffraction phenomena are explained by the use of the same principles, employing the most general formula for the secondary disturbance, and assuming

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